by those functions, and we have a long disquisition on the geometrical representation of the elliptic integral of the first kind by an algebraic curve; while there is no mention of the late John Riddle's discovery, that the arcs of the curves by which circles on the sphere are represented in Mercator's projection are directly given by, and absolutely co-extensive with, the elliptic integrals of the first kind, the amplitude being simply the longitude on the sphere. We think this quite as simple and as important as the discussion of the lemniscata. If we are to go into geometry at all, it might be as well also to make some allusion to Dr. Booth's discussion of the spherical conics, and to Mr. Roberts's integration of the Cartesians.

Then, again, we have an account of Jacobi's geometrical theorem in its original form, depending upon a family of circles having the same radical axis, while the corresponding theorem, depending upon circles having two inverse points in common, given by Chasles (see his "Géometrie Supérieure," cap. xxxi., p. 533), which much more directly represents both amplitudes and moduli, is not mentioned explicitly, although it is involved in the geometrical exposition given of Landen's theorem.

We have also been unable to find any account of Jacobi's reduction of the integral of the third kind to the form—

$$\int d\phi .\ \mathrm{E}\phi : \Delta\phi$$

The transformations of the functions are worked out with great completeness, the results being tabulated in some rather formidable-looking, but really very convenient, schedules. This part of the work is carried almost to an extreme.

On the whole the book is one of the most important contributions to mathematical literature which has appeared for a long time. It is well done, and covers ground that was previously but ill occupied. It is clearly printed, and the fact that the proof-sheets have been revised by Mr. J. W. L. Glaisher is a guarantee for the correctness of detail.

C. W. MERRIFIELD

OUR BOOK SHELF

Instruction in Photography. By Capt. Abney, R.E., F.R.S., &c., Instructor in Chemistry and Photography at the School of Military Engineering, Chatham. Third Edition. (London: Piper and Carter, Gough Square, Fleet Street, E.C., 1876.)

WE are very glad to find that Capt. Abney did not carry out the intention which he mentions in the preface of not producing another edition of his well-known "Instruction in Photography." That the little volume is widely known and appreciated is shown by the fact of its having reached a third edition, and we can only say that it well deserves its success. A photographer of the author's well-known skill and repute could not fail to be able to instruct others in his art, but when in addition he has gained large experience by continued practical teaching in such a school as that at Chatham his lessons become additionally valuable.

Capt. Abney does not enter much into theory, though he gives very good and simple accounts, illustrated by chemical equations, of the principal changes occurring during the processes described. We observe that he announces the forthcoming publication of a "Photography" among Messrs. Longmans' Text-books of Science, in which he proposes to deal more fully with the theoretical part of the subject. We shall look forward to this with considerable interest; meanwhile, for practical instruction in the art this little book distances all competitors.

R. J. F.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*]

Just Intonation

THE errors and oversights—in my paper in NATURE, (vol. xv. p. 159)—with which Mr. Chappell charges me, are imaginary. To make the matter clearer, the vibration numbers of a diatonic scale started from $\frac{3}{2}$ as a tonic are—

$$\frac{3}{2},\ \frac{27}{16},\ \frac{15}{8},\ 2,\ \frac{9}{4},\ \frac{5}{2},\ \frac{45}{16},\ 3.$$

In order to keep to the same part of the keyboard, let the last five notes be depressed one octave, and we get this series:—

$$1,\ \frac{9}{8},\ \frac{5}{4},\ \frac{45}{32},\ \frac{3}{2},\ \frac{27}{16},\ \frac{15}{8},\ 2,$$

where $\frac{3}{2}$ is the tonic, and 1 or 2 the subdominant. A similar explanation applies to the scale starting from $\frac{4}{3}$ as tonic. With respect to the "comma of Pythagoras," I am not aware of any "generally adopted miscalculation." *Who* was the real discoverer of that interval is a matter of no consequence; but in a system such as the Pythagorean, which was tuned by true fifths, it would have been not only a very natural but an essential inquiry, "What definite number of fifths corresponds with another number of octaves?" This, without at all necessitating the supposition of the existence among the Greeks of instruments of an immense range in octaves, would be but an easy arithmetical calculation resulting necessarily in the conclusion that there was no exact coincidence between fifths and octaves, but that twelve fifths differed by a very small quantity from seven octaves. This small difference is therefore very aptly termed the Pythagorean comma. Now in the equal temperament system twelve fifths just coincide with seven octaves, so that the despised comma of Pythagoras is really a measure of the error of the equal temperament fifth. In fact, putting P for the comma in question—

$$\mathrm{P} = \left(\frac{3}{2}\right)^{12} 2^{-7} \therefore\ 2^{\frac{7}{12}} = \frac{3}{2}\ \mathrm{P}^{-\frac{1}{12}}$$

so that if $2\,\mathrm{N}$ be the vibration number of the lower tone of an E T fifth, that of the upper tone will be $3\,\mathrm{N}\,\mathrm{P}^{-\frac{1}{12}}$, which is in error by $3\,\mathrm{N}(1 - \mathrm{P}^{-\frac{1}{12}})$ vibrations, giving rise to a number of

$$\text{Beats} = 6\,\mathrm{N}(1 - \mathrm{P}^{-\frac{1}{12}})$$

per second in the E T fifth. Not, however, that it is necessary to allude to Pythagoras or seven octaves to get those beats.

The grounds upon which Mr. Chappell declines to accept 24, 27, 30, 32, 36, 40, 45, 48, as representing the vibration numbers of the diatonic scale are not very clear, certainly; and repudiating these, he can of course have no sympathy with Colin Brown's keyboard.

To revert shortly to this, the subject of my previous communication,—in his new and very interesting work on "Temperament," Mr. Bosanquet has given a description of Colin Brown's keyboard, but in so peculiar a manner that it is really difficult to recognise the instrument at all, and neither its elegance nor simplicity are brought out as I think they should be.

A. R. CLARKE

Ordnance Survey, Southampton, January 9

South Polar Depression of the Barometer

I THINK it probable that on this subject Mr. Murphy's views and my own might have appeared more in harmony if we had neither of us expressed them with so much brevity. In my letter on Ocean Currents in NATURE, vol. xv. p. 157, I was incidentally led to speak of the barometric depression round the South as greater than that round the North Pole. In speaking

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of this superiority as "mainly due to superior evaporation in the water hemisphere generally," it did not occur to me that I could be misunderstood to mean that the excessive depression in high south latitudes is due to excessive evaporation taking place *within those latitudes*, an idea which, with Mr. Murphy, I regard as absurd.

The large areas of depression which the American meteorologists have termed the "Polar Cyclones" appear, on examination, to be themselves aggregates of those local depressions, or cyclones, which have penetrated either into the Arctic or Antarctic regions, and have there, either partially or wholly, coalesced. Local depressions starting from the edges of the great areas of excessive evaporation seem to be governed in their course by the distribution of relative humidity, and to be determined towards those districts in which precipitation is most in excess of evaporation. Consequently their forward development is, as a general rule—a rule to which there are in the northern hemisphere many important exceptions—somewhat towards the poles. As they advance between converging longitudes they commonly expand, and therefore become united, while the influence of the earth's rotation deflects their circulating currents further away from the points of lowest pressure. Mr. Murphy's view that the imperfection of the Arctic as compared with the Antarctic depression, is due to the amount of land in the northern hemisphere, and the local air-currents produced thereby, is not in opposition to my argument. Undoubtedly over Greenland the anticyclonic circulations predominate (except in the summer quarter) over the cyclonic. It is not improbable that somewhat analogous irregularities of pressure dependent on the distribution of land and sea may exist in high south latitudes. But I still think that it is to the middle latitudes of the two hemispheres that we must look in order to find the chief cause of the contrast between the Antarctic and Arctic depressions, for it is in the middle latitudes that the majority of the local depressions originate. In the southern hemisphere those latitudes are almost entirely occupied by surfaces in which evaporation is excessive. In the northern they are represented to a large extent by areas of relatively slight evaporation and predominant precipitation.

The correlation of wind and pressure-distribution is of a kind which can hardly be stated at the same time briefly and correctly. But if it is necessary to be concise, it seems more natural in every case to regard the distribution of pressure as the primary cause of the wind than to say "the cause of the depression round the Pole is the centrifugal force of the west winds."

Lutterworth, January 9 W. CLEMENT LEY

Sense of Hearing, &c., in Birds and Insects

MR. ROMANES (NATURE, vol. xv., p. 177) is not quite correct in supposing that the Death's Head is the only species of *Lepidoptera* known to "stridulate." Possibly the phenomenon is far more general than is commonly believed, although only few instances of its occurrence have been observed. In the current number of the *Entomologist's Monthly Magazine*, Mr. Swinton details the method in which a sound is believed to be produced by *Vanessa io* and *V. urticæ*, viz., by friction of a nervure of the hind-wings against a "filed" nervure in the fore-wings. *Chelonia pudica*, one of the tiger-moths, has long been known to produce a sound (*cf.* Solier, *Annales Soc. Entomol. de France*, 1837). In 1864, Guenée (*Ann. Soc. Fr.*, pp. 398–401) notices that the genus *Setina* possesses a tympaniform organ on each side of the breast, analogous to that found in the *Chelonia*, and in the same volume he is followed by Laboulbène, who gives an elaborate anatomical description of the organ in *Chelonia*, with figures (pl. 10). Another tiger-moth (*Euprepia matronula*) is said to stridulate (*cf.* Czerny, *Verhand. zool.-bot. Vereins in Wien*, 1859); and the existence of the phenomenon is (at least) suspected in members of other groups of *Lepidoptera*.

Without being able to prove it, I suspect that birds obtain a knowledge of the whereabouts of worms and subterranean larvæ by sight, and not by sound. In the case of the thrush, I think the excrement rejected to the surface guides the bird to the right spot. The starling during breeding-time feeds almost exclusively on the larvæ of *Tipula*. Here, again, I think it is sight, and not sound that aids the bird. True, in this case there is no rejected excrement on the surface, but there is something that may be equally significant to the eye of the bird, viz., the withered condition of the plants of grass, &c., telling a tale of the mischief that is going on below. Furthermore, is it not possible that if the movements of the larvæ below the surface cause sufficient *sound* to be heard above the surface, the movements of the bird should act as a warning, and cause the larvæ to cease feeding? The withered plant tells its own tale; if only flagging, but yet with some amount of vitality in it, the chances are that a larva is still at work at its roots; if entirely dead, then the larva has departed for another plant.

Confessedly in the case of the curlew and allied birds, the matter becomes very difficult of explanation, owing to the depth below the surface at which the food is found. But do these marine and other worms always keep at the depth to which the bird is obliged to penetrate in order to obtain them? *Solen* is believed to remain near the surface until warned that an enemy is near, when it descends with rapidity. The worm might also be ordinarily near the surface, and the slight movement thereon caused by its endeavours to bury itself deeper might result in its destruction. I throw this out as a suggestion, because it is hard to believe that sound produced by the movements of an annelid could be transmitted through nearly a foot of sand. There is yet another difficulty. In the case of the curlew the sound would have to travel nearly a foot *above* the surface before it reached the auditory organs of the bird.

Lewisham ROBERT M'LACHLAN

THE "CHALLENGER" COLLECTIONS

THE following "Preamble" to a list of observing stations, printed for the use of the naturalists engaged in preparing the account of the voyage, contains so much likely to interest naturalists generally that we think it useful to publish it in NATURE:—

The special object of the *Challenger* Exploring Expedition was to investigate the physical and biological conditions of the great ocean basins; and with this object in view, during an absence from England of three years and a half, and at intervals as nearly uniform as circumstances would permit, throughout a course of 68,890 miles, 362 observing stations were established.

The following list of these stations has been compiled for the use of those naturalists who have consented to assist in the working out of the scientific results of the expedition, with a view to their being published in an official account of the voyage. Interesting observations were made on land as opportunity occurred during the short periods of the *Challenger's* stay in port, and during her short visits to remote islands; but these observations were necessarily desultory and incomplete, and it has been decided to omit their consideration from the present work, and to publish such as may appear of sufficient value in the transactions of learned societies. The Official Report will thus consist strictly of an account of the additions which have been made to the knowledge of the physical and biological conditions of the ocean by the expedition.

At each station the following observations were made, so far as circumstances would permit. The position of the station having been ascertained—

1. The exact depth was determined.
2. A sample of the bottom averaging from 1 oz. to 1 lb. in weight was recovered by means of the sounding instrument, which was provided with a tube and disengaging weights.
3. A sample of the bottom water was procured for physical and chemical examination.
4. The bottom temperature was determined by a registering thermometer.
5. At most stations a fair sample of the bottom fauna was procured by means of the dredge or trawl.
6. At most stations the fauna of the surface and of intermediate depths was examined by the use of the townet variously adjusted.
7. At most stations a series of temperature observations were made at different depths from the surface to the bottom.
8. At many stations samples of sea-water were obtained from different depths.
9. In all cases atmospheric and other meteorological conditions were carefully observed and noted.

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